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Before the memory fades: Some notes on the indigenous forests of the Philippines

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Summary. The extent of forest cover of the Philippines is discussed. The different vegetation types and special plant communities, as well as their species associations, that used to exist or which are still found are described.

Early this century, W.H. Brown (Brown & Matthews 1914, Brown 1919) surmised that the Philippines was originally entirely covered with wet evergreen rain forests, dominated in the lowlands by the emergent crowns of the dipterocarp timber trees. Whether this was so or not we shall never know because, even by his time, the Philippines had become extensively deforested as is indicated in Whitford's (1911) map. This map, though sketchy, makes telling comparison with Whitmore's of 1984 (Whitmore 1984b). Now less than one million hectares of primary rain forests of all types and at all altitudes remains (Jaacko Poyry 1984).

Deforestation was in the beginning most extensive in the driest and most seasonal regions, and has long obliterated all aboriginal primary, semi-deciduous forest in these parts, if such had ever existed. Elements of such a flora do exist, though they are rather few and I will return to discuss this further. Deforestation has not been most acute in drier climates because of the increased hazard of fire only. The dry season also permits greater control of water for irrigation, and provides a reliable season for harvesting grain, both fundamental for permanent agriculture and the sustainment of dense rural populations such as have existed in northern-east Luzon for hundreds, perhaps thousands, of years.

Forest cover

Subsequently, deforestation has been most intense in the evergreen forests, more recently in

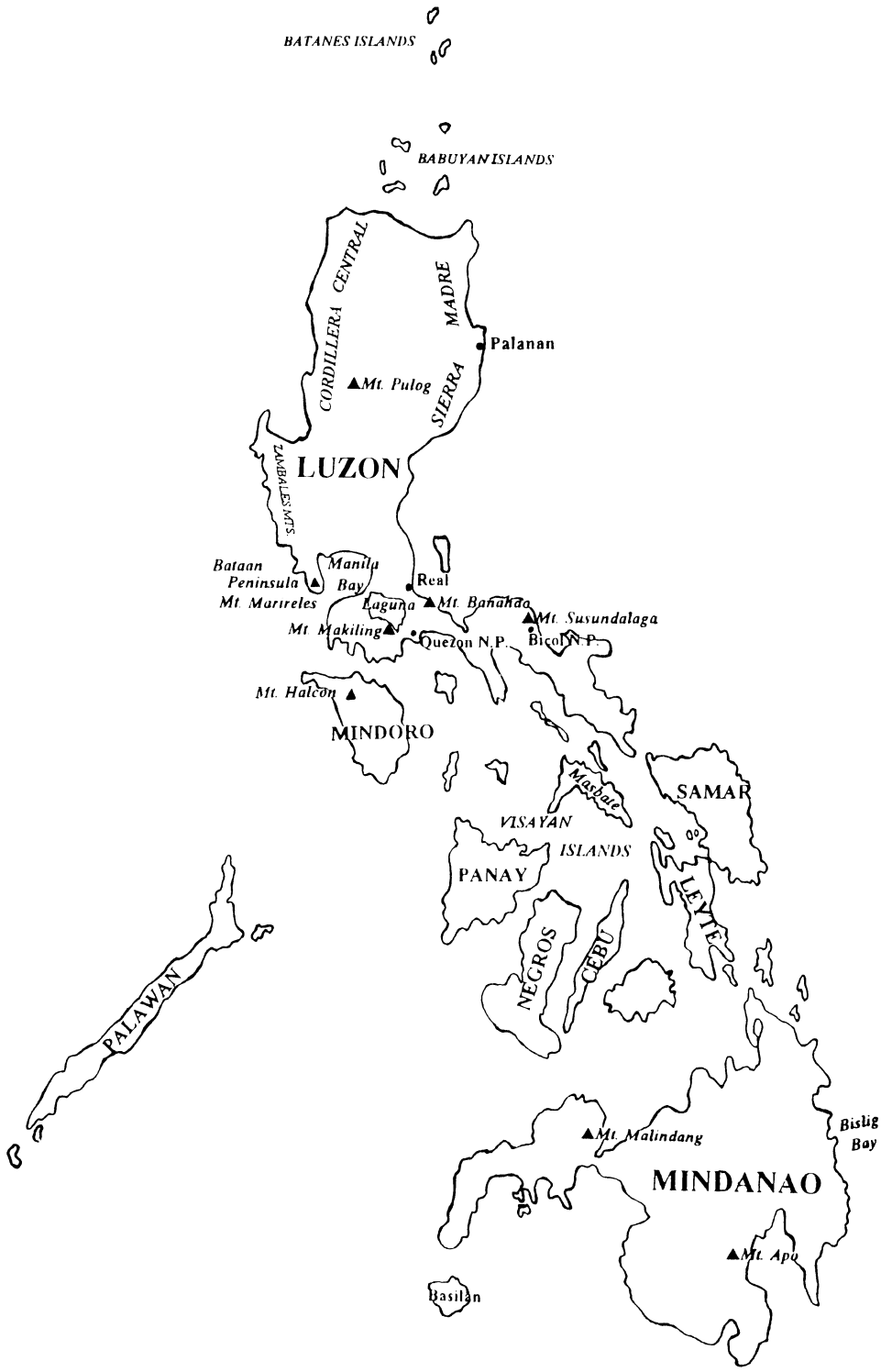

Fig. 1. The Philippines: places mentioned in the text.

Mindanao. Though Whitford (1911) had already established that 40% of the land area of the Philippines had been converted to grasslands and 17% to second-growth forests, leaving 10% for cultivation and, even then, a mere 33% under virgin forests of all kinds, Myers (1980) still wrongly surmised that three-quarters of the land remained forested at the end of the second world war. Myers' review documented deforestation following the acceleration in forest exploitation and illegal settlement in the sixties (Anon. undated, Bureau of Forest Development 1977, Lachowski & Dietrich 1978, Lachowski *et al.* 1978, Roque 1978; all in Myers 1980.) True, 57% of the country legally comprised "forest lands" in 1965. By 1971, this had dropped to 44.24%, with an estimated 1720 km^2 per annum of deforestation. In 1976, 38.2% was claimed to be forests of all types, including secondary scrub, but this figure was disputed and a more conservative estimate of 27% or 81,000 km^2 also suggested. More recent estimates (DENR 1990) place total forest cover in 1990 at 20% and primary forest variously at an alarming 2.7% or 4.5% having dropped from 37% in 1940. Less than one million hectares of inland old-growth forest remains. Some 380,000 families of swidden agriculturalists (*kaingineros*) occupied 23,000 km^2 of forest lands in 1976, and by 1990 this area had increased to 66,000 km^2 (DENR 1990).

In 1923, Merrill (1923) estimated the population of the islands to have been somewhat under ten million. The census of 1983 indicated 52 million, and population increase continues at more than 2.5% per annum. Under these circumstances, and the political instability which has existed in rural areas to greater or lesser extent since independence, the prospects of any extensive areas of natural vegetation surviving much beyond the end of this century are not good. Overwhelmingly though, the endemic flora as well as fauna is confined to the now beleaguered residual tracts of natural vegetation. All the same, it is important to be aware that patches of primary forest still do exist in botanically little-explored areas of critical biogeographical interest including Basilan, parts of Palawan and the Batanes and Babuyanes islands (Rabor 1977). Investigation of these still barely known floras is of highest priority.

In former times, under conditions of relative population stability, land unsuitable for irrigation was farmed by the swidden system known in the Philippines as *kaingin*, whereby hill rice is interplanted with a variety of vegetables and other useful plants for one to about five years (longer in seasonal regions), then abandoned to return to woody regeneration for up to fifteen years. Planted areas were small and set in the forest matrix, so that species of the mature forest, which as a rule have poor seed dispersal or whose seeds are dispersed by animals which are themselves confined to forest, can reinvade once a canopy is reestablished by pioneer species. This form of agriculture is still practised by the few remaining isolated forest communities of Luzon, Mindoro and elsewhere, but has become insignificant under the pressure from dispossessed villagers and lowlanders, seeking out a living from the land without the constraints imposed by inherited traditional values or the security of ownership.

Soil deterioration, but most particularly burning over large areas beyond the range of tree

seed dispersal, leads to the increasing elimination of woody vegetation. The old-growth climax species are the first to go. Secondary, pioneer and successional species are then eliminated by *cogon* (*Imperata cylindrica*), the deep-rooting perennial grass which, once established, outcompetes all woody vegetation in regeneration immediately following fire. In the absence of fire for several years in succession, woody vegetation does slowly return and can shade out the *cogon*, but this rarely happens in the Philippines. The open grasslands with scattered trees, known as *cogonales*, have likely been a feature of the seasonal parts of the Philippines, including north-central and west Luzon, western Mindoro, and Cebu for centuries. The existence, in western Mindoro and western Luzon, of *Pinus merkusii* in these *cogonales*, which is a species requiring bare soil for its successful establishment and a strong dry season for its cones to open and seed to be released, is testimony to the persistence, at least in small patches, of grasslands in these driest lowland areas over geological time periods.

Now, *cogonales* are rapidly expanding in other regions and particularly in the Visayan island group where, in the last fifty years, logging has been followed by illegal farming and then by rapid population growth. The woody vegetation which formerly revegetated abandoned swiddens, known in Philippines as *parang*, does still abound in the derelict landscapes of the deforested wetter, eastern regions and occupies extensive patches in exploited forests where the residual stand has been severely damaged by logging operations. In practice, logging in the Philippines, at least until recent years, was followed by illegal settlement, though the Bureau of Forests has attempted a last stand (Weidelt & Banaag 1982). Once the population builds up, even *parang* become eliminated. The future landscape of the Philippines will consist of irrigated rice fields, intensively cultivated multiple species orchards and vegetable gardens and, overwhelmingly, the sterile rangelands which are the *cogonales*—unless investment in reforestation is made. Of these anthropogenic types, home orchards and vegetable lots are concentrated on fertile upland soils where good communications provide inexpensive access to markets.

The secondary *parang* vegetation of the Philippines differs little in structure or successional characteristics from that on similar soils and climates in other parts of the region. It is dominated by small trees, particularly in the Euphorbiaceae, Rubiaceae, Theaceae and Malvaceae, and by vines particularly in Rubiaceae and Apocynaceae. These species are characterized by rapid and often continuous growth, short life cycles, light brittle wood, early flowering, high fecundity and production of abundant small seeds which are predominately bird- or wind-dispersed (see Whitford 1911). Many are thought to possess seed dormancy though little experimentation has been carried out to test this. The dense mass of stems makes this vegetation impenetrable without a *machete* in the early years following establishment.

In the wettest regions, *parang* vegetation tends to form a dense canopy of tightly packed leaves, under the dark shade of which little grows except for patches of gingers

(Zingiberaceae), which may establish early in succession and temporarily exclude other woody competition. In regions affected by drought or typhoons, water stress and wind damage reduces the canopy density, and species with smaller leaves and open crowns have competitive advantage. In the north-west, dense bamboo thickets dominated by the species *Schizostachyum lumampao* may arrest tree succession (Whitford 1906, Merrill 1907, Anon. 25 September 1944).

At high altitudes a rich shrub flora, including genera in Rubiaceae such as *Psychotria*, and in Acanthaceae such as *Strobilanthes*, play an important part in forest succession. In the more seasonal, western and northern parts of Luzon's mountain provinces, extensive montane grasslands populated by temperate *Aster, Anemone, Viola* and *Senecio* exist. The low endemism of this vegetation, and the persistence of forest relics up to the highest peaks, suggest that nearly all of it is secondary. Its species have presumably existed in the Philippines for a long time though, and may have formerly occupied patches of natural grassland on rocky summits, land slips and in forest pockets.

The primary forest, notwithstanding its small residual area and uncertain future, is the most important vegetation cover for the naturalist and biologist. It is several times more rich in plant species than secondary forests and grasslands. Endemism of both plants and animals is concentrated almost to exclusion in the primary forests. There are no endemic plants which are not, at least in part, associated with the primary forest. For these reasons, the nature of the primary forest habitat will now be elaborated in greater detail than its current area and prospects would otherwise justify.

The dry land primary vegetation of the Philippines has received remarkably few accounts. Fortunately though, it was subject to classic early studies by Whitford (1906, 1911) and by Brown & Matthews (1914). The following summary review is based principally on an interpretation of their work, and on the excellent account of eastern Mindanao forests in Weidelt & Banaag's (1982) book; also in the light of my own experience in Philippine forests and of my studies of similar forests in nearby Borneo (Ashton 1964, 1969, 1982 and in prep.; Ashton & Hall 1992); and on Whitmore's (1984a) general account of the primary vegetation of this region. A useful summary, based on earlier accounts, was also published towards the end of the second world war by the Allied Geographical Section, South-west Pacific Area (Anon. 25 September 1944).

Mixed Evergreen Dipterocarp Forest

There is little doubt that mixed evergreen dipterocarp forest, of remarkably uniform species composition, was the predominant even if not the sole aboriginal lowland forest type of the Philippines. In its typical composition, it does not occur above 400 m, though stands of good form can occasionally occur to 900 m (e.g., Wyatt-Smith 1958, for Negros). Some

dipterocarp species, including a few which are confined to higher altitudes, occur up to 1500 m. It may be significant that no truly montane dipterocarp species occur in the Philippines as they do in Borneo, where some are occasionally found as high as 1750 m (Ashton 1982).

The mature structure of Mixed Dipterocarp forest, the formal name for this lowland forest formation, shares certain characteristics throughout the region. It consists of three strata. These are determined by crown heights and their branching characteristics at maturity, and the reproductive characteristics of the tree species comprising them (Whitmore 1984, Yap 1982).

The lowest stratum, or understorey, consists of saplings of species which reproduce in higher strata, in mixture with small trees which characteristically flower and fruit in the shade of the forest. Most saplings, and some of the understorey species are monopodial with horizontal branches, resembling the familiar fir trees of temperate climates. A few have broad crowns, but nearly all have a diffuse leaf canopy. Shrubs, that is woody plants which branch from ground level, are rare in the lowlands. Tree species in the understorey are thought almost without exception to be insect-pollinated, unlike in the neotropics where bats and hummingbirds are important pollinators in the understorey. Flowering can be sparse and more-or-less continuous, or intense and intermittent. Most species bear few fruit, which are mostly of medium size or large. In most, seeds are dispersed by vertebrates. A high proportion of understorey tree species (over 30% in Borneo; Ashton 1969) are dioecious (unisexual).

The greatest number of tree species, however, occupy the middle stratum, which often comprises the main canopy of the forest. These are species which will only flower after their crowns have grown into direct sunlight, but whose crowns do not emerge far above those of their neighbours. Among these, the crowns are generally conical or dome-shaped, with many ascending branches. Leaves are more densely clustered than in the understorey, and are predominately spirally arranged, bunched towards the twig endings. Flowering is generally seasonal, sometimes supraannual. Fruit production is frequently heavy. Relatively few species are dioecious (Ashton 1969).

A small group of species of the main canopy, particularly but not exclusively in the monopodial tree families Annonaceae and Myristicaceae are cauliflorous. These may flower while still in the understorey so that their characteristics are truly intermediate between those of the two strata. Cauliflory is a common reproductive strategy among true understorey species also.

Crowning the forest is the emergent stratum. This comprises species whose mature crown base is at the level of or above the main forest canopy. The crowns are broad, hemispherical or umbrella shaped with the leaves clustered towards the ends of the outermost twigs. The

leaves of emergent tree are, on average, smaller and more leathery than in other strata. Flowering is generally periodic, often supraannual, and intense. The fruit are predominately wind-dispersed, or gyrate on falling. Almost all species possess bisexual flowers. Throughout the Philippines, dipterocarps comprise the vast majority of emergent trees, and a higher proportion of the emergent canopy in the lowland forests than has been recorded in other regions of the Far East. In the Philippine forests as a rule 90% of emergent trees in undisturbed forest belong to this family (see e.g. Wyatt-Smith 1958). Their magnificent timbers, Philippine mahogany or *lauan*, and *yakal*, were the main export timbers during the heyday of logging as elsewhere in the region.

Herbs are uncommon in the mature phase of the lowland forest, occurring in patches often dominated by one species, either where the leaf litter does not settle such as steep banks or rock exposures, or in sunny habitats such as river banks. They also occur as epiphytes, but lowland forests of the Far East are not as densely ornamented with epiphytes as their equivalents in the New World where two important epiphyte families, Bromeliaceae and Cactaceae occur which are absent in Asia.

Variation in the Mixed Dipterocarp Forest

Though the overall species composition of Philippine Mixed Dipterocarp forest is remarkably uniform, except to a limited degree in the more seasonal areas, there is considerable regional and topographic variation in structure, and in the relative abundance of the species components.

This variation appears to be correlated with soil water relations, and with storm frequency which may influence forest dynamics as well. Whitford (1906) and Brown & Matthews (1914) described dipterocarp forests in Bataan and Laguna in west Luzon, and also northern Negros, which serendipitously well exemplify the major structural variation which occurs in these forests throughout the islands. The forest classification adopted by Weidelt & Banaag for the Mindanao forest differs therefore only in detail. The descriptions of all these authors are so closely reminiscent of forests on a variety of sites in Borneo, where detailed soils and other habitat data have been recorded (Ashton 1964 and in prep., Ashton & Hall 1992) that reasonable understanding of the various forest community types can be achieved.

The grandest forest described by Brown & Matthews were those of northern Negros, an aseasonal region with fertile arable soils derived from basic volcanic material. The canopy was of exceptional stature and commonly exceeded 65 m. The emergent stratum formed a continuous phalanx of tall buttressed giants, crown to crown, a sight seldom seen in mixed tropical forest. In the gloom cast by their lofty crowns, the main canopy was sparse (see Wyatt-Smith 1958), while the understorey too was of low density. Though dipterocarp seedlings were apparently frequently abundant, few survived into saplings. This forest

description closely matches that of Mixed Dipterocarp forests on fertile well-drained lower slopes and bottomlands in northern Borneo. To stand in such a forest is an unforgettable experience, evoking the grandeur, serenity and mystery of a gothic cathedral. The sounds of birds echo through the cavernous understorey; the moist fertile soil emits a sweet odour of fermentation recalling temperate broadleaved woods in autumn. In the shades of the understorey, punctuated by shafts of sunlight which penetrate the occasional clerestories high above, it can be so open that one can walk about almost unhindered. Early foresters, because of the concentration of the timber among the biggest trees and the paucity of the intermediate-sized regeneration, described such stands as "overmature". In fact, the main canopy stratum is so poorly represented that these forests are definitely two-storied, with a prominent gap between the emergent crowns and those of the understorey (see Ashton & Hall 1992 for a good illustration). Where a giant has been felled by a squall, the forest initially regenerates as a dense stand of *Macaranga* and other large-leaved pioneers, along with established saplings of dipterocarps many of which respond by attaining growth rates comparable to the pioneers (Ashton & Hall 1992).

These forests are remarkably unproductive for vertebrate life. The dipterocarps, which typically fruit supraannually in the aseasonal regions of the Far East, do not provide a staple; their resinous fruits are eaten by parakeets, alone among the birds. The low density of lower strata bespeak low fruit production, though large strangling figs are prominent among the crowns of the forest giants. It is the asynchronous fruiting of these figs which sustains the main, year-round supply of food, and thus determines the carrying capacity of many of the vertebrate frugivores (McGregor 1920).

In Borneo, such forests are confined to sites where soil water stress probably never occurs. Such habitats appear to permit survival of those trees which can eventually outshade their competitors. They are those which can grow tall, and which can develop dense, shady crowns. Keeping the densely packed leaves cool in the heat of the day necessitates high water loss. The water required has to be drawn to a great height, and must always be freely available to the roots in the soil. In the Philippines such forests, known as *lauan* type (Anon. 25 September 1944, Paa & Gerardo 1966) were widespread in lowland habitats sheltered from the typhoons and drying coastal onshore breezes. But their habitat was at a premium for conversion to agriculture.

In the plains and along river valleys a distinct form of these forests, characterized by the presence of *hagachac*, *Dipterocarpus validus* and called "*lauan-hagachac* type" (Anon 25 September 1944) occurred. A few patches may remain in eastern Mindoro and Mindanao.

The forest in western Laguna described by Brown & Matthews was in the foothills of Sierra Madre. Also experiencing an aseasonal wet climate, this forest is nevertheless substantially shorter than the *Lauan* type forest. Further, though the stand density of emergent dipterocarps is again exceptionally high, providing an even emergent canopy profile as in

the *lauan* type, the main canopy and understorey here is dense also, with abundant dipterocarp regeneration of all sizes which obscures any semblance of vertical stratification.

I have seen such forests in the Sierra Madre near Real, Quezon; and in the Bicol National Park on the boundary of the Camarines Provinces, also in eastern Luzon. The emergent canopy, in which *tiaoung* or *tanguile*, *Shorea polysperma* is commonly the dominant species, differs strikingly from the *lauan* type forest in that the crowns, and the branches within them, tend to be isolated from one another and the leafage diffuse, both allowing high sunlight penetration. Ng (1977) described similar isolation of leaves derived from separate branches and crowns, which he termed crown shyness, in monocultures of *Dryobalanops aromatica* in Peninsular Malaysia. It appears to be caused by shoot abrasion by wind movement. During a typhoon I witnessed in the forest in Real, I was struck by the minimal amount of damage, beyond stripping of leaves, which accompanied the storm. Wind speeds of such velocity are local and rare in Borneo, where they can completely flatten hundreds of hectares. I later also witnessed such destruction in both primary forest and in plantations of pioneers at Bislig Bay, eastern Mindanao, to the south of regular typhoon paths. It would seem that in the forests of the eastern and windward hill slopes of the Philippines, and particularly Luzon where typhoon occur at least annually, canopy structure is substantially modified by these frequent storms. In consequence, the emergent trees are shorter, and their canopy more diffuse.

The favourable light climate of the understorey of these widespread forests, whose canopies are apparently affected by typhoons, might explain why the Philippines were unique in possessing extensive dipterocarp forest in which regeneration of intermediate sizes is abundant, permitting management by a selective system. Nowhere else in the region is this the case.

In their most extreme manifestation, on the windward coast of the northern Sierra Madre as in the beleaguered forests still surviving around Palanan, the frequency of strong typhoons is such that the storms strip off twigs as well as leaves. In the years following, the branches become swathed in leafy epicormic shoots, looking almost like insulated water pipes! The trees themselves, evenly tall at about 40 m often exceed 5 m girth, but taper. They survive the hurricanes like the masts of windjammers. Walking beneath the open latticed canopy is like being in a Victorian conservatory, and the dense elegant fronds of wild bananas, aroids, Marantaceae, understorey palms and tree ferns outcompete the tree regeneration, which is sparse.

At Real, I noted along road cuts that the emergent dipterocarps in this forest type possess stout sinker roots which descend from beneath their buttresses for at least two meters. Often, there is strong vegetational contrast between abutting windward and leeward slopes, with the leeward side supporting denser, moister forests with more heterogeneous canopy structure (see Jacobs & Mendoza 1968).

Towards the upper altitudinal limits of *lauan* type forest, at 400–950 m, a forest similar in stature and canopy structure to that just described, in which *Shorea polysperma* is also frequently dominant, and *Shorea almon*, almon, more abundant than in the lowlands, but here also with abundant oaks and chestnuts (Fagaceae: *Lithocarpus*, *Castanopsis*) and oil fruits (Elaeocarpaceae: *Elaeocarpus*) beloved of pigeons, occurs generally throughout the islands (Whitford 1906, Everett & Whitford 1906, Wyatt-Smith 1958). This is known as the *tanguile*-oak type (Anon. 24 September 1944), or the Upper Hill Dipterocarp forest (Weidelt & Banaag 1982).

Whitford (1906) in his classic study of forest on the extinct volcanic cone of Mariveles, in the southern Zambales Mountains of Bataan in western Luzon, described a strong correlation between forest structure, and also composition, and physiognomy there. The rain forests of this region typify those in areas with a strong dry season, where expected evapotranspiration exceeds precipitation over five continuous months. Here, the tallest trees do not exceed 40 m, and occur as scattered emergent dipterocarps or small groups, in a forest of lower average canopy height. The tallest trees occur on alluvium in gullies and on the lower slopes. On the ridges the forest superficially resembles that at Real and Bicol, but is characteristically often dominated by a single dipterocarp species, *apitong* (*Dipterocarpus grandiflorus*), *tanguile* (*Shorea polysperma*) or white *lauan* (*Shorea contorta*). *Apitong*, which occurs abundantly and on all topography in the seasonal west, is distinctly a ridgetop tree in the aseasonal parts of the Philippines, as it often is elsewhere in its wide range which includes peninsular Malaysia and Indo-Burma.

D. grandiflorus, like *S. polysperma* and *S. contorta*, has coriaceous leaves which are borne diffusely in the crown. As in the *tanguile* forests on the eastern windward slopes, the Zambales *apitong* forest have a dense understorey and diffuse main canopy. Here, intermediate-sized regeneration of dipterocarps is less abundant than in the main part of the typhoon belt, but more so than in the great forests of northern Negros and eastern Mindanao. *Apitong* flowers annually (Sabado & Maun 1959), but dipterocarp seedlings here suffer high mortality in the first few dry seasons following establishment. Reestablishment in gaps is particularly prone to drought-induced mortality (Whitford 1906).

Forest with abundant *apitong* are termed *lauan-apitong* type (Anon. 24 September 1944) or *apitong-lauan* association (Wiedelt & Banaag 1982). The open canopy structure, and dense understorey with abundant dipterocarp regeneration, recall the *seraya* (*Shorea curtisii*) forests of peninsular Malaysia which also manifest single-species dominance. They also occur in the most arid habitat in their lowland humid tropical region: high or coastal ridges below the cloud base (Whitmore 1984a).

In the mostly seasonal climate of Palawan, where *Shorea* trees have never been recorded and are apparently absent (presumably for historical reasons), species of *Dipterocarpus*,

particularly *D. grandiflorus*, dominate the canopy forming what Weidelt & Banaag (1982) call the *apitong* association.

A further dry evergreen forest type is found widespread on low dry ridges in the less seasonal parts of the Philippines, especially where the hills come down to the coast. Here the dipterocarp forests are generally short and with relatively even canopy, the trees slender and dense in all stories. These forests are characterized by abundant dipterocarp hardwoods in *Hopea* (*H. philippinensis*), and *Shorea* (*S. guiso, S. falciferoides, S. astylosa*) and a wider than usual range of other species in the upper canopy stratum. They vary in composition, apparently according to subtle variation in habitat conditions. Collectively they are termed the *yakal-lauan* type (Anon. 24 September 1944). Weidelt & Banaag (1982) recognized separate *apitong-yakal* and *yakal-Hopea* associations in eastern Mindanao.

Dry seasons throughout the Philippines vary greatly in duration from year to year. An extreme drought afflicted eastern Borneo and Mindanao, normally both aseasonal regions though both with low mean annual rainfall, less that 2300 mm in southeast Borneo, variously 1000–2000 mm in parts of eastern Mindanao, in 1982. It was noted in Borneo that mortality affected emergent trees disproportionately, with up to 30% mortality (Leighton & Wirawan 1986) and that it affected some species more than others (Leighton & Wirawan, personal observations). Occasional extreme droughts, which affect some regions and some soils more than others, may be a principal cause of the uneven canopy structure of many mixed rain forests, and the low stand density of emergents. If frequent, these droughts may also limit species richness in the emergent stratum.

Though neither Whitford nor Brown & Matthews described them, tall Mixed Dipterocarp forests with uneven canopy and scattered emergents, such as are the predominant type in Malaysia, Sumatra and Indonesian Borneo, also occur widely in the aseasonal wet lowlands of the Philippines south of the hurricane zone. These are the mixed *lauan* type forests of Weidelt & Banaag (1982). In the Philippines, soils of those regions generally have relatively high clay content and base status, hence a high water-retaining capacity. Nevertheless, mean annual rainfall is usually less than 2000 mm, and can be as low as 950 mm (except along the east coast where it can reach 5000 mm; lowland rainfall in Borneo varies between 2500 mm and 4000 mm except in the southeast). The rainfall in the south of the Philippines is principally orographic. Nevertheless the evenly distributed rainfall suggests that these southern and southeastern forests contain the richest tree flora in the islands. The complexity of the forest structure may provide additional opportunity for specialization into structural niches.

Semi-deciduous Forest and Savanna

On the dry coastal hills that fringe northwestern Luzon to the leeward of the mountains, and also near the east coast of Mindoro, there occur patches of semi-deciduous forest, now

much mutilated, that is often dominated by *molave*, *Vitex parviflora* (Maun 1958). The trees are unbuttressed, crooked, frequently branching low, and form an uneven canopy rarely exceeding 30 m tall. Associated species include *Pahudia rhomboidea*, *Sindora supa*, *Euphoria didyma*, *Lagerstroemia pyriformis*, *Pterocarpus indicus*, *Kingiodendron alternifolium*, *Toona calantas*, *Intsia bijuga*, and *Wallaceodendron celebicum* (Asiddao & Nastor 1958, Maun 1960).

Of the species listed some, particularly *narra* (*P. indicus*), *ipil* (*I. bijuga*), and *kalantas* (*T. calantas*) are confined to moist valley sites in this terrain. Merritt & Whitford (1906) and Merritt (1908) described extensive floodplains in western Mindoro dominated by a magnificent stand of *narra*, with *T. calantas*, *Dipterocarpus validus*, *Intsia bijuga*, *Pometia pinnata*, *Alstonia scholaris*, *Koordersiodendron pinnatum*, *Bischofia javanica* and other species, widespread in the Far East on similar sites, subordinate. Remnants of a similar forest occur in several parts of Palawan (Hilleshog, undated). Several of these species are also widespread on mesic valley sites in the Philippines, as scattered individuals in the dipterocarp forest, often in late successional stands.

In Palawan, patches of semi-deciduous forest on steep slopes occur still also, in which common emergents include *Pterocymbium tinctorium*, *Pterospermum diversifolium*, *Hymenodictyon* sp. and *Garuga floribunda* (Hilleshog, undated).

Molave forest, in a more-or-less modified form, occurs on dry leeward ridges and spurs throughout the islands, though rarely in the east. *Molave* is, however, an important component of late secondary succession in some aseasonal regions.

The flora indicates connections with similar forests to the south and east in Sulawesi and New Guinea, and due west in Indochina (Moist Deciduous forests of Champion, 1936) where it is associated with fertile, mesic sites in similar strongly seasonal climates. The Dry Dipterocarp forests of Indo-Burma and their associated flora (Champion 1936) are completely unrepresented in the Philippines, presumably because the infertile lateritic or sandy soils on which they occur are unrepresented too.

The driest sites in western Mindoro and western Luzon, being the most prone to dry-season fire, are no longer forested. Here, open grassland savannas extend over large areas. The survival of stands of the lowland seasonal tropical pine, *Pinus merkusii*, suggests that fire has always been a natural factor there albeit much more local and less frequent than at present. This is because pine seedlings only establish on bare soil free of competition, a condition which can only be provided by fire, or disturbance such as landslips, in the humid tropics. Though landslips are common in the mountains where the other Philippine pine grows, they are infrequent in the rolling lowlands of the seasonal north-west.

Vegetation on limestone and ultrabasic rock

Two rock types universally bear distinctive vegetation. These are limestone, and ultrabasic volcanic rocks such as serpentine. Unfortunately, no account of the vegetation of either exists for the Philippines as a whole. Limestone is widespread in the islands, with major outcrops in Luzon, Samar and Mindanao. The vegetation, particularly where the rock is low and hard as in Quezon National Park, Luzon and in the strongly seasonal regions such as the hundred islands area in north-east Luzon, reflects the free-draining, arid substrate. It is short, dense, and with an abundance of deciduous species. In seasonal regions it is apparently identical to *molave* forest on other substrates, but in aseasonal it includes many species, particularly herbs, which are characteristic of this type. In the wettest areas the rock faces, particularly in partial shade, support a rich herbaceous flora of Gesneriaceae, Begoniaceae and other families. On the softer, more recent limestones and in the wet aseasonal regions such as eastern Mindanao, the forests on limestone differ little in species composition from those on adjacent fertile soils derived from sedimentary or volcanic rocks, and are of the zonal mixed type. But they are of shorter than average stature, and the absence or sparsity of emergents suggests proneness to periodic drought.

Extensive areas of ultrabasic rocks are found on Palawan (Whitmore 1984a, Hilleshog undated) in the northern Zambales mountains and Dinagat Island near the north-east tip of Mindanao, and in the northern Sierra Madre. Many smaller areas are dotted through the islands. Here, the only accounts describe a short, even-canopied vegetation including genera such as *Casuarina* which are associated with heath forest, characteristic of podsols in Borneo to the south-east. There appears to be high local endemism (C. Ridsdale, pers. comm.); the only known endemic genus is *Xanthostemon* (Myrtaceae). It is on these rocks that *almaciega*, *Agathis philippinensis*, a tropical montane conifer, in Palawan occurs down to low altitude. This, too, suggests that the ultrabasic habitat is an infertile one in which the soils are freely draining and their surface layers, in likelihood, acid.

Mangrove Forest

Of lowland vegetation formations, there remains to mention the mangrove forests. Philippine mangroves, though rich in plant species by world standards, contain no endemics. The thorough account given by Brown & Fischer (1918) indicates their close floristic and structural similarity to those of northern Borneo. Owing to the absence of major rivers, few mangroves in the Philippines have ever been extensive. Those around Manila Bay in particular, and many elsewhere were intensively managed for a long time and have disappeared. Now, as elsewhere in the region, the mangroves have been tragically overexploited, and wherever possible drained for agricultural development or converted to shrimp farms.

Montane Forest

The highest mountains of the Philippines, Mt. Apo and Mt. Pulog, are only 2954 m and 2929 m high, respectively, and only some ten others exceed 2000 m. Forest still grows in places to the highest peaks, and may be assumed to have once covered the mountains except on exposed rocks and in limited frost hollows (see Steenis 1972). Most of the major, and many minor, mountains are volcanic cones. Noteworthy exceptions are the extensive Cordillera Central of north-central Luzon, and the Sierra Madre chain running down Luzon's northeast coast which re-emerges intermittently down the eastern side of those islands which abut the Mindanao trench.

Whitmore (1984a) has summarized the zonation of vegetation which occurs on Far Eastern tropical mountains. The vegetation is influenced by topography, by the elevation of the cloud base during the day, and by the occurrence of frost. The size, shape and degree of isolation of tropical mountains greatly influences the altitude of vegetational change, principally through their influence on the altitude of the cloud base, and the extent and downward movement of frosted air at night. Regional climates may also have some influence. Extremes of this so-called mass elevation effect are to be found on Philippine mountains.

A number of travelers' accounts, and accounts of particular plant groups on Philippine mountains, exist. One of the most thorough ecological descriptions is the early one by Brown (1919). This is based principally on a careful comparison of the vegetation of the extinct volcanos Makiling (Maquiling), 1020 m and Banahao, 2300 m in Luzon. Koch (in Weidelt & Banaag 1982) has given a good account of floristic and structural zonation between 800 m and 2000 m on mountains in eastern Mindanao.

Philippine mountain ridges are frequently windy during the day, on account of orographic air movements up the slopes or, in the north, the passing of the trade winds. This adds to water stress on ridges below the cloud base. On large mountain massifs, heating of air above the land surface leads to elevation of the altitude at which the dew point occurs, sometimes to as high as 2000 m. Thus, the summit of the isolated Mt. Makiling is almost always bathed in cloud during the hottest part of the day. The same is the case for the higher Mt. Banahao, though there the cloud base on sunny days is seldom below 1500 m; but in the Mountain Provinces of Luzon the clouds during the dry season may only penetrate the forest canopy on ridges above *c.* 1800 m, leaving rain shadows in the intervening valleys. Thus, whereas the slopes of the Banahao cone are clothed throughout with wet evergreen forest, and their climate is to some extent ameliorated by the shadow of the clouds which daily gather around its summit, the ridges and valleys at middle elevation in the Mountain Provinces are among the most arid habitats in the islands, more arid in fact than the valleys below. Nowadays, almost all evergreen forest between 800 m and 2000 m in the mountain provinces has been destroyed by cultivation and ensuing fire, except along ridges exposed

to the moist north-east monsoon. It has been replaced by a fire-climax grassland dominated by the grasses *Saccharum spontaneum* and *Miscanthus sinensis*, the bracken fern *Pteridium aquilinum* and the woody perennial composite *Eupatorium adenophorum* (Wyatt-Smith 1958). But the most conspicuous feature of the landscape is the tree overstorey which consists of a pure stand of *Pinus kesiya*, here called the Benguet Pine (Jacalne & Lizardo, 1958). This pine, like *P. merkusii* at lower elevations requires a strong dry season for its cones to open so that its seeds can be released. These pines only successfully establish in bare soil. Originally Benguet pine, with its wind-borne seeds, was presumably a pioneer on the vast landslips which are so characteristic of the long steep unstable slopes of the Mountain Provinces, but now fire has allowed it to greatly extend its habitat.

Elsewhere in the Philippine mountains, the dipterocarp forests give way up the slopes, by way of *tanguile*-oak type forests, to a shorter (to 30 m tall) even-canopied evergreen forest dominated by members of the oak (*Castanopsis* and *Lithocarpus*: Fagaceae) and laurel (Lauraceae) families though many main canopy species from lower elevations persist (Brown 1919). *Syzygium* (Myrtaceae) also increases. This type can start on suitable sites as low as 800 m as on the windward slopes of the eastern coastal mountains of Mindanao, whose summits do not reach 2500 m (Koch in Weidelt & Banaag 1982), and generally extend to *c.* 1500 m. Though single-species dominance rarely occurs in these forests, their tree species richness even in respect of the southern Philippine mountains is noticeably much poorer than in analogous forests in Borneo and continental Asia. These forests occur in cooler, usually cloudier, conditions than the dipterocarp forest, but they are only intermittently swathed in cloud during the day. Epiphytic ferns and orchids become more abundant. A notable feature is the abundance of shrubs in the understorey, notably of Rubiaceae and Acanthaceae (*Strobilanthes*). Shrubs in Urticaceae, notably *Oreocnide trinervis*, and *Saurauia* are common in gaps and gullies. Herbs, including ferns, *Selaginella* and *Elatostema* (Rubiaceae) also form extensive ground cover. Monocotyledonous climbers, notably *Freycinetia* and aroids, are abundant where the forest is disturbed. On very steep spurs and ridges the elegant small tree *Astronia* (Melastomataceae), with a broad diffuse crown like an understorey maple, is a common and distinctive feature of Philippine forests at this altitude; tree ferns (*Cyathea*) may also be abundant.

Above 1500 m, especially towards the upper parts of sheltered slopes and ridges, subtropical and tropical gymnosperms become important in the canopy. On the upper slopes and rim of Mt. Banahao, and elsewhere it is fascinating to see the Asian yew, *Taxus wallichiana*, forming a mixed canopy with the Australian *Podocarpus neriifolius* and *P. imbricatus*. Koch (in Weidelt & Banaag 1982) mentions these *Podocarpus*, plus *P. philippinensis* and also *Phyllocladus hypophyllus*, a curious Australasian gymnosperm with fruit arising from leaf-like stems which occurs also in Borneo, from the wet mountains of eastern Mindanao, but not *Taxus*. Koch also mentions *Symplocos* (Symplocaceae), *Acer niveum* (Aceraceae) and *Engelhardia* (Juglandaceae).

Ridges and upper slopes within the cloud base are at once distinguished by the characteristic form of their vegetation, which is generally of low stature, with an open canopy in which small leathery leaves predominate, and in which the branches and trunks and often the ground are carpeted in cryptogamic epiphytes such as mosses and ferns. This type well merits its common name, mossy forest. The filmy ferns *Trichomanes* and *Hymenophyllum* become abundant, as do orchid species. *Usnea* lichen festoons the canopy branches in seasonally dry localities. *Medinilla* (Melastomataceae) and begonias are common ground plants. *Astronia* and the species associated with it lower down remain abundant. The trees *Eurya* (Theaceae), *Elaeocarpus*, *Weinmannia* (Cunoniaceae), *Drimys* (Winteraceae), *Clethra* and, on the highest and most exposed ridges, members of Myrtaceae (*Syzygium*, *Leptospermum*) are important, and shrubby rhododendrons and vacciniums are common. In gaps, temperate herbaceous genera, notably *Rubus* brambles, can be abundant.

Plant ecologists have come to describe this vegetation as Upper Montane forest (Whitmore 1984). This is, on balance, a better term than mossy forest because the tree species component is not necessarily always accompanied by the epiphytes. Physiognomically very similar forests, accompanied by some at least of the tree species, can occur below the cloud base on skeletal soils along narrow defiles, both in the Philippines and in Borneo. Physiognomically, the forest has much in common with that on some ultrabasic rocks too, in Palawan for instance (Hilleshog undated). The term Upper Montane forest should therefore not be interpreted as meaning that the forest is only found at the highest altitudes. It occurs at a very wide range of altitudes on exposed narrow ridges and peaks. I have even seen mossy Upper Montane forest at only 400 m on an isolated volcanic cone, Susundalaga in Camarines Norte, Luzon, not far from the east coast and in the path of the wet north-easterly monsoon. The isolated summit of Mt. Makiling bears more densely mossy Upper Montane forest then do the more extensive summits of Mt. Banahao, 2300 m, and its associate peaks San Cristobal and Banahao Lucban. Only on the very highest peaks of the Mountain Provinces, Apo and Malindang in Mindanao, and Halcon in Mindoro does mossy Upper Montane forest extend over large areas of the slopes as well as ridges.

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